

Palynology and Palynofacies studies of fifteen shallow borehole samples from some parts of Delta and Bayelsa states, Niger Delta, Southern NIGERIA

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ABSTRACT

Rock Samples from fifteen shallow boreholes in some parts of Delta and Bayelsa states, Southern Nigeria was analysed for Palynology and Palynofacies studies to determine their paleoecology/paleoenvironment of deposition. The sample intervals range from 0.0 - 0.5m in depth and was drilled using hand auger. The samples were described and prepared into palynological slides following the non-acid sodium hexa metaphosphate method. The analysis of the palynological preparations yielded abundant pollen, spore, fungal spores, dinoflagellates and fresh water algae. Particulate organic matter was also recovered from the palynological preparations for palynofacies analysis. The particulate organic matter included opaque and translucent phytoclast, amorphous organic matter and palynomorphs. The palynological recoveries from the samples were presented in species total recovery charts and cumulative percentage distribution charts, while the particulate organic matter, making up the palynofacies were presented in percentage distribution table. The palynological recoveries provided data for biozonation of the studied area into A – D biozones. The study area is part of the Benin Formation and ranged in geologic age between Miocene to Recent. This is indicated with the occurrence of marker (index fossils) species such as *Echitricolporites spinosus*, *Pachydermites diderixi*, *Stereisporites sp*, *Striatricolpites catatumbus*, *Crassoretitrites vanraadshooveni*, *Monoporites annulatus* and *Nympheapollis clarus*. The palynofacies data generated indicated that the biozones identified was the results of paleo ecological changes between mangrove swamp, tropical rain forest to fresh water swamp.

Key words: Palynology; palynofacies; palynomorphs; biozonation; paleoenvironment.

INTRODUCTION

The Niger Delta is an oil bearing sedimentary basin located in southern Nigeria, it lies laterally from the Abakaliki-Benue Trough towards the Calabar Flank, adjacent to the Benin Flank and opens up to the Atlantic Ocean [1]. The Niger delta developed as the third phase of depositional cycle in the southern Nigeria with the transgression of the Paleocene sediments that gave rise to the development of the Proto-Niger Delta and the present Niger Delta [2]. During the Tertiary, the delta built out into the South Atlantic Ocean [3], [4]. Over the period, the delta plain has prograded southwards trending towards the oceanic crust, [5]. The rate of sediment build up and subsidence gave rise to the

formation of depocentres in the Niger Delta [6]. These depocentres were the results of gravity tectonics that affected the Agbada Formation and had been completed before the deposition of the Benin Formation [5]. The study area lie within longitudes 05° 06' 00"E and 6° 18' 00"E and latitudes 04° 48' 00"N and 06° 18' 00"N (Figure 1) covering parts of Delta and Bayelsa state in the Niger Delta, southern part of Nigeria. The study area comprised of fifteen sampled points for which palynofacies and palynological analysis were carried out to generate particulate organic matter components/kerogen preserved in the rock samples through palynological sample preparations and analysis. The particulate organic matter components included

equidimensional black plant debris, equidimensional brown plant debris, bladed shape, granular plant debris, cellular plant debris and microfossils.

MATERIALS AND METHODS

The research work was undertaken in two stages, the first stage was the field stage and involved reconnaissance and detailed field mapping exercise. Samples were collected for lithologic descriptions and palynological preparations during the detailed field mapping. The second stage was the laboratory stage and involved laboratory sample description, preparations, microscopic analysis, interpretations and report writing.

SAMPLING

Fifteen samples were recovered from shallow boreholes drilled in parts of Delta and Bayelsa

states during the detailed field work. The boreholes were drilled using hand auger to a depth of 0-0.5 meters. The samples were composed using the “Pinch method”. The pinch method according to [7], involved collecting 10 pinches of soil throughout each sampled location of about 50 to 100 square meters. These pinches were combined into one sample, in a sterile, plastic bag and then sealed. This was done to avert the possibility of over-representation of a single pollen type. The samples collected from different locations were well-labelled with sample and location number, then kept in a sample bag and stored in a dry place. The hand auger and hand trowel were washed thoroughly with water to ensure samples were not contaminated.

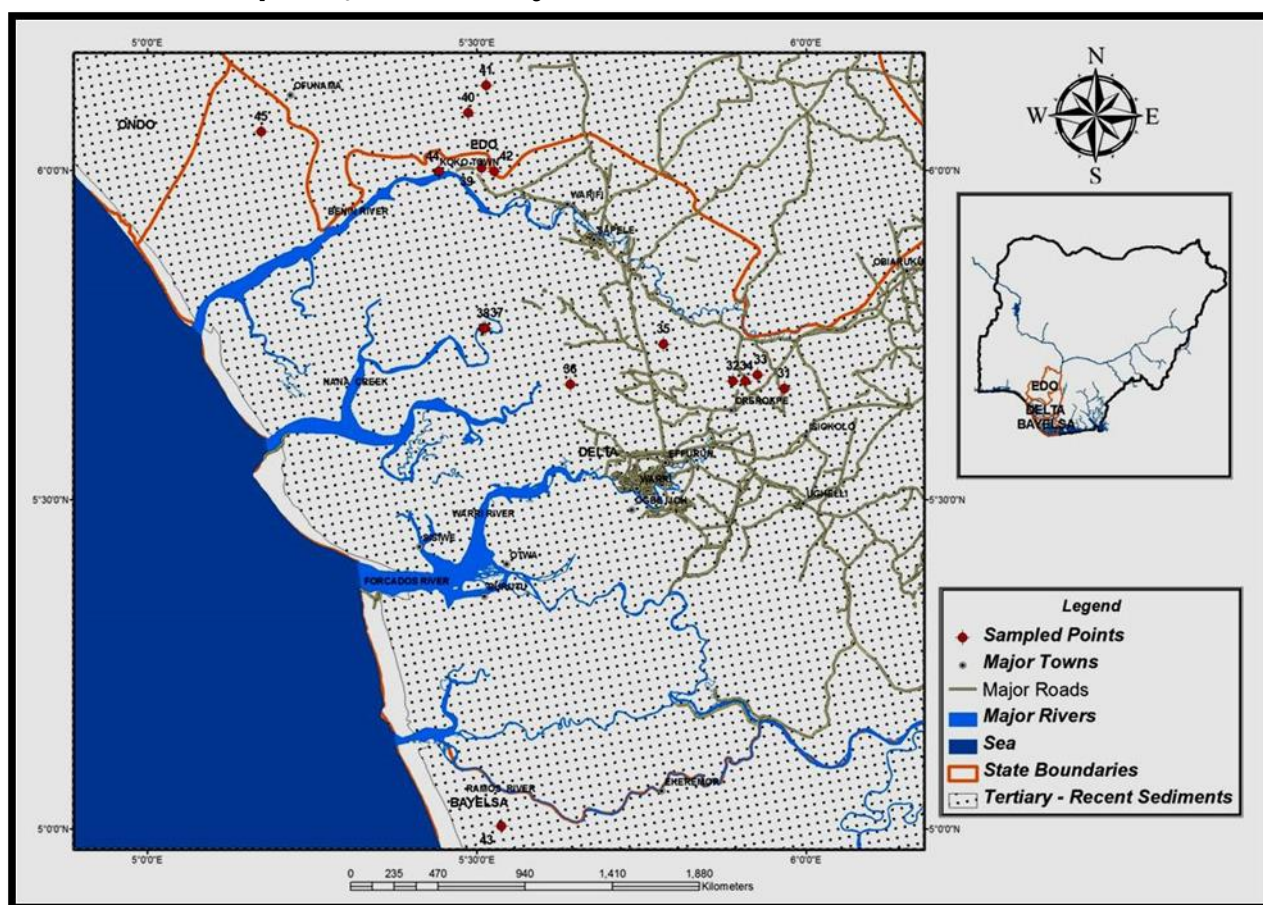


Figure 1: Location map of the study areas showing the sampled points

Table 1: Showing sampled numbers, towns, coordinates and sample field conditions

Sample No.	Towns	Latitude	Longitude	Condition of Sample
31	Oghara Two (Delta State)	05°58' 01.1"N	05°40' 56.3"E	Wet
32	Ovade, Oghara Town (Delta State)	05°53' 19.3"N	05°40' 47.7"E	Wet
33	Oghara Main Town (Delta State)	05°55' 35.3"N	05°41' 47.8"E	Wet
34	Ethiope West Town (Delta State)	05°54' 26.6"N	05°42' 47.6"E	Wet
35	Ibaba Lume Town (Delta State)	05°47' 03.1"N	05°44' 09.3"E	Wet
36	Okpe Town (Delta State)	05°30' 34.7"N	05°45' 34.5"E	Wet
37	Argaru Oropopo Junction (Delta State)	05°30' 45.7"N	05°45' 38.5"E	Wet
38	Erememukah Warien Ughelli (Delta State)	05°30' 34.7"N	05°45' 36.8"E	Wet
39	Iyede Town Ughelli (Delta State)	05°30' 24.8"N	06°00' 14.5"E	Wet
40	Oghor Town Ughelli (Delta State)	05°29' 13.0"N	06°05' 14.8"E	Wet
41	Emevor Along Uguweh Road (Delta State)	05°30' 52.0"N	06°07' 46.9"E	Wet
42	Evwereni Town (Delta State)	05°31' 34.1"N	05°59' 54.4"E	Wet
43	Evweru Town (Delta State)	05°32' 12.6"N	05°04' 15.9"E	Wet
44	Aven Town (Delta State)	05°26' 31.9"N	05°56' 54.5"E	Wet
45	Sagbama (Bayelsa State)	05°10' 21.8"N	06°04' 31.2"E	Wet

THE LABORATORY ANALYSIS:

The lithological and textural characteristics of the samples were derived by the use of hand lens and physical examination in the laboratory. The samples studied were treated with diluted Hydrochloric acid to test for the presence of carbonaceous materials.

25g each of the fifteen (15) samples collected from the field were weighed with a weighing balance and placed in fifteen plastic cups, labelled according to their various sample and location numbers. The samples were soaked with warm water for thirty minutes and two tea-spoonful of Sodium Hexametaphosphate salt were added and stirred for twenty minutes. The samples were washed through a set of nested sieve of 90µm, 75µm and 53µm under a running tap water. The filtrate was thoroughly washed with water using the 10µm mesh nylon sieve. The residue was swirled on a 24cm diameter watch glass.

The residue was stained with Safranin O in a mild alkaline medium, diluted, washed out with water and stored in small glass centrifuge tubes and labelled.

A drop of dilute hydrochloric acid and two drops of diluted solution of white gum was added to the residue. Few drops of the residue were pipetted onto a clean dry rectangular cover slip and allowed to dry on a hot plate.

Norland glue was smeared on a glass slide on the hot plate at a gentle heat and the dried cover slip was mounted on to the slide, pressed evenly to drive away air bubbles and were allowed to dry. The prepared slides were cleaned, labelled correctly and stored after cooling. The prepared slides were studied under a transmitting light, polarizing microscope and the palynomorphs recovered identified. The photomicrographs of the palynomorphs recovered were taken using

digital camera attached to the transmitting light, polarizing microscope.

RESULTS

The samples were analysed for Lithology, Palynofacies, and palynology which generated data for palynological zonation, age, Paleoecology and Paleoenvironment interpretation.

LITHOLOGY

The lithological and textural characteristics of the samples corresponded to sand and clay with the sand grains exhibiting fine to medium grained, and well sorted with rootlets. The sand grains are sub-angular to sub-rounded and light brown to dark brown as shown in (figure 2). The sands were not sticky, while the clays were very sticky. The samples studied were treated with diluted Hydrochloric acid to test for the presence of carbonaceous materials.

PALYNOFACIES

The [8] palynofacies analysis procedure was followed in analysing the samples of the study area. The components of the palynofacies included cellular plant debris (CP), bladed shape debris (BS), equidimensional black debris (EQB), equidimensional brown debris (EQBr), microfossils (MF) and granular debris (GD) as shown in Table 2.

PALYNOLOGY

The recoveries of palynomorphs varied from one geographic location to another. The recoveries from the samples were arranged using the sample's coordinates (latitudes) in a descending order, starting from the highest latitude (north to south). Pollen, spores and fungal spores were encountered in almost all the locations with sporadic occurrence of foraminifera test lining, Dinoflagellates, Algae, Acritach and Diatoms. The summary of the International Journal of Innovation (2018), Volume 8, Issue 1, Page(s):1-11

total palynomorphs recoveries from the sample analysis is shown in figure 3. The percentages distributions of palynomorphs recovered at each location are worked out in Table 3. The percentage distribution chart of the various palynomorphs recovered are presented in figure 4.

Quantitative analysis of the sample recoveries where generated as follows:

Numerical Count = Total number of each palynomorph group per sample.

Total Count = Sum total of all the numerical count per sample.

Percentage Count = $\frac{\text{Numerical count}}{\text{Total count}} \times \frac{100}{1}$

DISCUSSION

The data generated from the sample analysis were applied to palynological zonation, age, Paleoecology and Paleoenvironment interpretation as summarized in figure 5.

BIOZONATION

Biozones are the smallest biostratigraphic unit. Each biozone is characterized with fossil associations (assemblages) within an ecological niche. These ecological niches varied from one to another with the introduction of two to three new palynomorphs.

Four biozones were delineated with in the study area. Some zones were delineated using a single paleo environmental diagnostic specie while others were delineated using two or more palynomorphs (assemblage zones). The assemblage zones were recognized based on variations in the fossil taxa, abundance of specimens or both and on First Appearance Datum (FAD) and Last Appearance Datum (LAD). The assemblage zones may indicate ecologic facies, age or both. The zones are as follows:

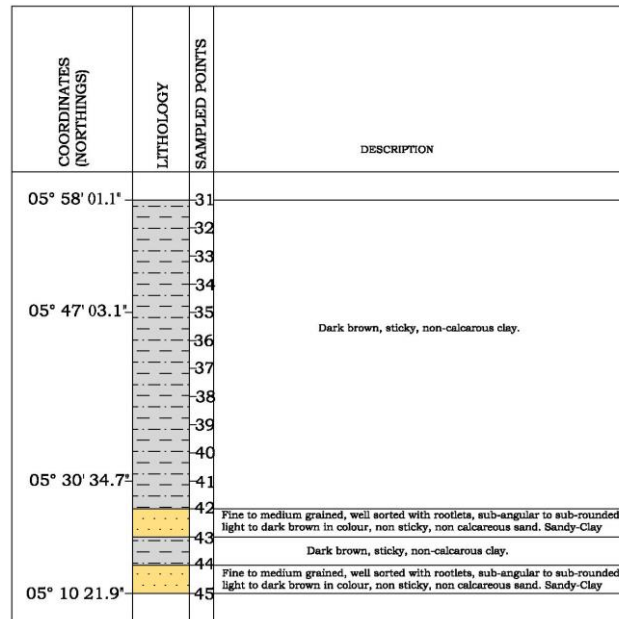


Figure 2: Lithology of the study area.

Table 2: Percentage distribution of palynofacies recovered from the study area.

S/NO	Cellular plant debris	Bladed shape debris	Equidimen- sional black debris	Equidimen- sional brown debris	Micro-fossils	Granular debris	Palynofacies colours	Degree of maturation	Hydrocarbon generation/reservoirs
31	4	7	34	45	9	1	Dark brown	Mature	Oil
32	5	4	33	39	10	6	Dark brown	Mature	Oil
33	-	5	45	35	13	2	Dark brown	Mature	Oil
34	8	11	31	33	17	-	Light brown	Mature	Oil
35	10	3	32	37	16	4	Light brown	Mature	Oil
36	-	-	25	35	15	2	Light brown	Mature	Oil
37	12	4	27	36	18	4	Dark brown	Mature	Oil
38	-	6	23	35	20	3	Dark brown	Mature	Oil
39	5	3	29	38	21	4	Light brown	Mature	Oil
40	4	3	30	36	22	5	Light brown	Mature	Oil
41	3	3	31	37	25	2	Light brown	Mature	Oil
42	5	-	26	34	30	6	Light brown	Mature	Oil
43	-	-	35	42	20	3	Light brown	Mature	Oil
44	3	4	26	35	30	2	Light brown	Mature	Oil
45	-	5	27	36	29	3	Light brown	Mature	Oil

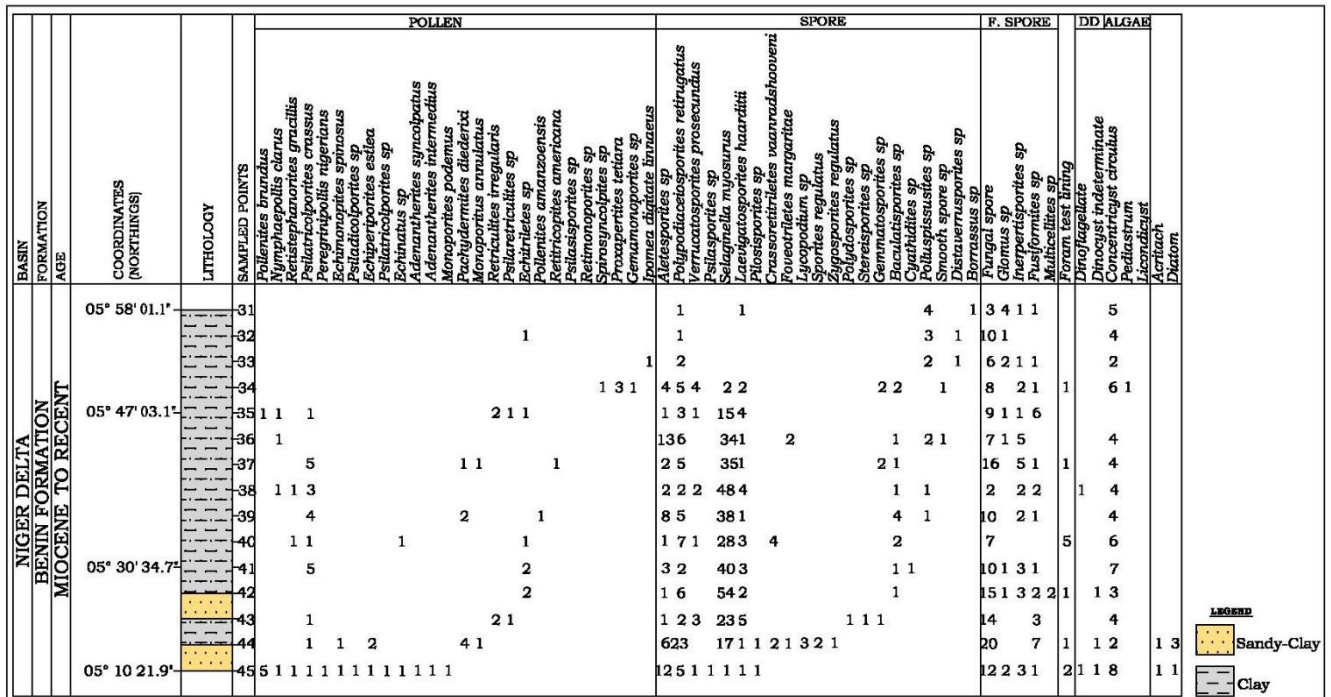


Figure 3: Summary of the total fossil recoveries from the sample analysis

Table 3: Percentages distributions of palynomorphs recovered at each location.

Percentage Distribution of Palynomorphs recovered in Sample 31.			
Palynomorphs	Numerical Count	Total Count	Percentage Count (%)
Pollen	-	-	-
Spore	7	21	33
Fungal spore	9	21	43
Fresh water algae	5	21	24
Percentage Distribution of Palynomorphs recovered in Sample 32.			
Palynomorphs	Numerical Count	Total Count	Percentage Count (%)
Pollen	1	21	5
Spore	5	21	24
Fungal Spore	11	21	52
Algae	4	21	19
Percentage Distribution of Palynomorphs recovered in Samples 33			
Palynomorphs	Numerical Count	Total Count	Percentage Count (%)
Pollen	2	20	10
Spore	6	20	30

Fungal spore	10	20	50
Algae	2	20	10
Percentage Distribution of Palynomorphs recovered in Sample 34.			
Palynomorphs	Numerical Count	Total Count	Percentage Count (%)
Pollen	5	51	10
Spore	24	51	47
Fungal spore	11	51	22
Foram test lining	1	51	2
Algae	10	51	19
Percentage Distribution of Palynomorphs recovered in Sample 35.			
Palynomorphs	Numerical Count	Total Count	Percentage Count (%)
Pollen	6	47	22
Spore	24	47	50
Fungal spore	17	47	14
Percentage Distribution of Palynomorphs recovered in Sample 36.			
Group	Numerical Count	Total Count	Percentage Count (%)
Pollen	1	78	1
Spore	60	78	77
Fungal spore	13	78	17

Algae	4	78	5
Percentage Distribution of Palynomorphs recovered in Sample 37.			
Palynomorphs	Numerical Count	Total Count	Percentage Count (%)
Pollen	8	81	10
Spore	46	81	57
Fungal spore	22	81	27
Foram lining	1	81	1
Algae	4	81	5
Percentage Distribution of Palynomorphs recovered in Sample 38.			
Palynomorphs	Numerical Count	Total Count	Percentage Count (%)
Pollen	5	80	6
Spore	55	80	69
Fungal spore	12	80	15
Dinoflagellate	1	80	1
Algae	4	80	6
Acrinach	2	80	3
Diatom	1	80	1
Percentage Distribution of Palynomorphs recovered in Sample 39.			
Palynomorphs	Numerical Count	Total Count	Percentage Count (%)
Pollen	7	81	9
Spore	57	81	70
Fungal spore	13	81	16
Algae	4	81	5
Percentage Distribution of Palynomorphs recovered in Sample 40.			
Palynomorphs	Numerical Count	Total Count	Percentage Count (%)
Pollen	3	62	5
Spores	41	62	66
Fungal spore	7	62	11
Foram test lining	5	62	8
Algae	6	62	10
Percentage Distribution of Palynomorphs recovered in Sample 41.			
Palynomorphs	Numerical Count	Total Count	Percentage Count (%)
Pollen	5	77	7
Spores	50	77	65
Fungal spore	15	77	18
Algae	7	77	10
Percentage Distribution of Palynomorphs			

recovered in Sample 42.			
Palynomorphs	Numerical Count	Total Count	Percentage Count (%)
Pollen	9	99	9
Spores	62	99	63
Fungal spores	23	99	23
Foram test lining	1	99	1
Dinoflagellate	1	99	1
Algae	3	99	3
Percentage Distribution of Palynomorphs recovered in Sample 43.			
Palynomorphs	Numerical Count	Total Count	Percentage Count (%)
Pollen	3	61	5
Spores	37	61	61
Fungal spores	17	61	28
Algae	4	61	6
Percentage Distribution of Palynomorphs recovered in Sample 44.			
Palynomorphs	Numerical Count	Total Count	Percentage Count (%)
Pollen	9	99	9
Spores	55	99	56
Fungal spores	27	99	27
Foram test lining	1	99	1
Dinoflagellate	1	99	1
Algae	2	99	2
Acrinach	1	99	1
Diatom	3	99	3
Percentage Distribution of Palynomorphs recovered in Sample 45.			
Palynomorphs	Numerical Count	Total Count	Percentage Count (%)
Pollen	25	89	28
Spores	32	89	36
Fungal spores	19	89	21
Foram test lining	2	89	2
Dinoflagellate	2	89	2
Algae	8	89	9
Acrinach	1	89	1
Diatom	1	89	1

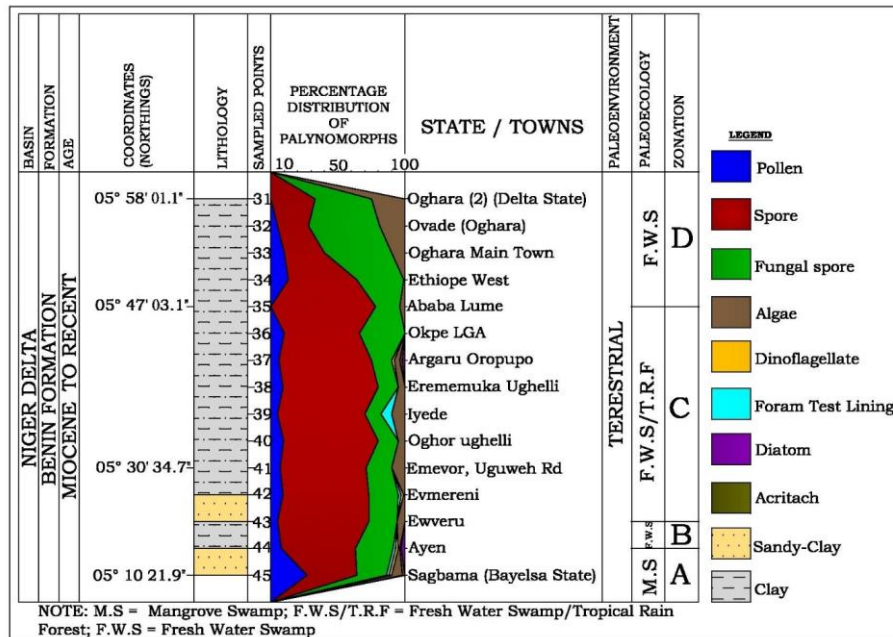


Figure 4: Percentage distribution of palynomorphs and towns where samples were taken

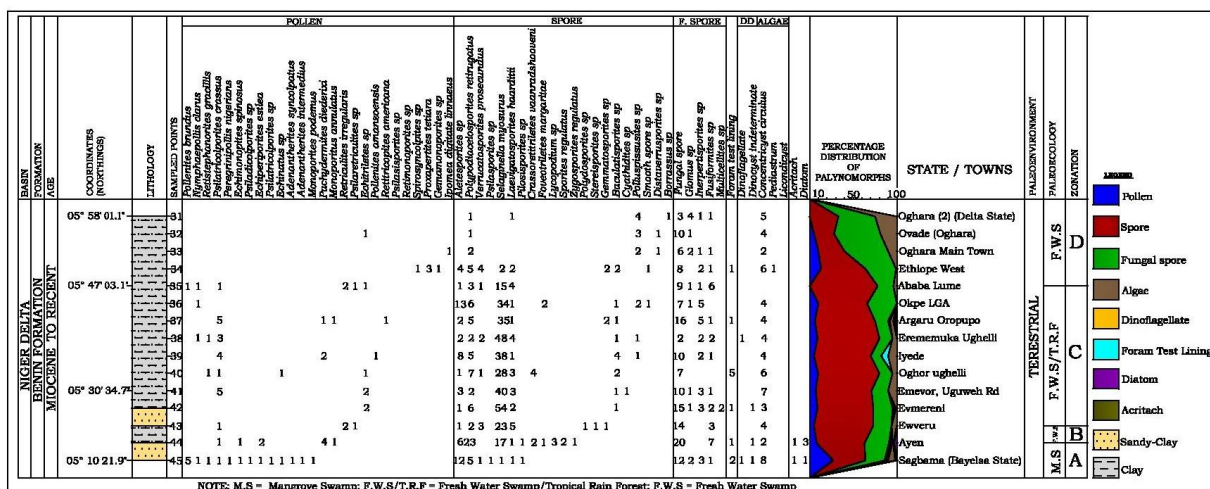


Figure 5: Summarised distribution chart showing biozonation, age, paleoecology and paleoenvironment of deposition of the study area

ZONE A

Zone A is characterized at the base with occurrences of pollen grains such as *Pollenites brundus*, *Retistephanoporites gracillis*, *Psilatricolporites crassus*, *Peregrinipollis nigericus*, *Echimonopites spinosus*, *Psiladicolporites sp.*, *Echiperiporites estlea*, *Psilatricolporites sp.*, *Echinatus sp.*, *Adenantherites syncolpatus*, *Adenantherites intermedius* and *Monoporites podemus*.

Spores such as *Aletesporites* sp., *Polypodiaceiosporites* *retirugatus*, *Verrucatosporites* *prosecundus*, *Psilasporites* sp., *Selaginella* *myosurus*, *Laevigatosporites* *haardtii* and *Pilosisorites* sp.

The top of zone A is marked with the appearance of spores such as *Foveotrilites margaritae*, *Lycopodium* sp, *Zygosporites regulatus* and *sporites regulates*.

ZONE B:

Zone B is marked with the introduction of pollen grains such as *Retriculites irregularis* and *Psilaretriculites* sp and spores such as *Polydosporites* sp, and *Gemmatosporites* sp.

ZONE C:

Zone C is marked with the appearance of pollen grains such as *Echitriteles* sp, *Pollenites amanzoensis* and *Retitricopites Americana* and with the appearance of spores such as *Baculatisporites* sp, *Cyathidites* sp, *Polluspissusites* sp and smooth trilete spores.

ZONE D:

Zone D is marked with the appearance of pollen grains such as *Spirosyncolpites* sp, *Proxerapertites tetiara*, *Gemmamonoporites* sp and *Ipomea digitate*, with spores such as *Distaverrusporites* sp and *Borrassus* sp.

AGE

The age of the study area was determined using the index/marker fossils encountered from the analysis carried out. The index fossils recovered were *Echiperiporites estelea*, *Peregrinipollis nigericus*, *Pachydermites diederixi*, *Stereisporites* sp, *Striatricolpites catatumbus*, *Crassoretitriteles vanraadshooveni*, *Echiperiporites echinatus*, *Monoporites annulatus* and *Nympheapollis clarus*. The occurrence of these index fossils suggested that the samples studied ranged from Miocene to Recent in age, which is conformable with the age of Benin Formation of the Niger delta [9].

Paleoecology/Paleoenvironment

Interpretation

The palynological assemblages in zone A were commonly rich in pollen, spores and fungal spores. *Concentricyst circulus* alga was found to be present in low quantity with very few benthonic foraminifera test lining, Dinoflagellate, Acritach and Diatoms

indicated mangrove swamp for the zone A. The presence of few marine environmental indicators in a pollen, spores and fungal spores dominated assemblage indicated infiltration of marine water into the terrestrial swampy environment [9].

Zone B is rich in spores and fungal spore with few pollen and freshwater algae indicating freshwater swamp.

Zone C is dominated by *Psilatricolpites crassus*, *Selaginella myorusus*, *Aletesporites* and *Polypodiaceiosporites retrugatus*. Fungal spores and *Concentricyst circulus* algae were well represented in this zone. Benthonic foraminifera test lining was poor. Acritach and diatom were not seen indicating freshwater swamp tropical environment.

Zone D is highly dominated by Spores, fungal spores and algae. Pollen was poorly represented with absence of Dinoflagellate, benthonic foraminifera test lining, Acritach and Diatom indicating freshwater swamp.

CONCLUSION

The palynological data recovered from the studied area yielded abundant pollen which was of the Palmae family except in samples 33, 32 and 31 where there was reduction in the number of pollen species. Spores, fungal spores and algae were also recovered in all the samples analysed with rare to no occurrence of Marine species. This indicated that the paleoenvironment of the samples studied is terrestrial/continental with few marine incursion in some of the borehole locations. The paleoecology of the study area conformed to mangrove – freshwater swamp following the palynofacies interpretation. The studied samples were part of the Benin Formation of the Niger Delta, with a geologic age of Miocene – Recent based on occurrences of *Echiperiporites estelea*,

Peregrinipollis nigericus, *Pachydermites diderixi*, *Stereisporites* sp, *Striatricolpites catatumbus*, *Crassoretitriteles vanraadshooveni*, *Echiperiporites echinatus*, *Monoporites annulatus* and *Nympheapollis clarus*.

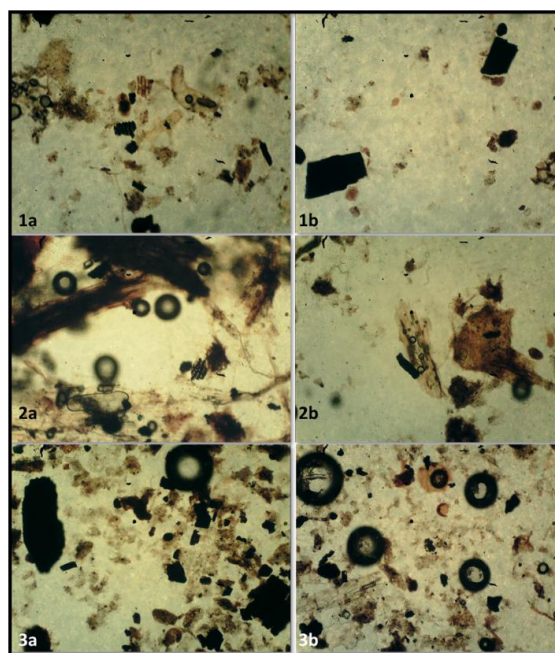
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EXPLANATION TO PLATE 1

Figs. 1a&b: Palynofacies components of sample 31
Figs. 2a&b: Palynofacies components of sample 32
Figs. 3a&b: Palynofacies components of sample 33

PLATE 1



EXPLANATION TO PLATE 2

- Fig 1: *Concentricyst Circulus* (Sample 31, 400x)
Fig 2: *Polypodiaceiosporites Retrugatus* (Sample 31, 400x)
Fig 3: *Concentricyst Circulus* (Sample 31, 400x)
Fig 4: *Fusiformisporites* sp (Sample 31, 400x)
Fig 5: *Concentricyst circulus* (Sample 34, 400x)
Fig 6: *Echitriteles* sp (Sample 32, 400x)
Fig 7: *Concentricyst circulus* (Sample 34, 400x)
Fig 8: *Concentricyst circulus* (Sample 34, 400x)
Fig 9: *Aletesporites* sp (Sample 34, 400x)
Fig 10: *Verrucatosporites* sp (Sample 34, 400x)
Fig 11: *Aletesporites* sp (Sample 34, 400x)
Fig 12: *Spiniferites* sp. (Sample 34, 400x)
Fig 13: *Concentricyst circulus* (Sample 32, 400x)
Fig 14: *Crassoretitriteles crassus* (Sample 34, 400x)

- Fig 15: *Verrucatosporites sp* (Sample 34, 400x)
 Fig 16: *Selaginella myosurus* (Sample 34, 400x)
 Fig 17: *Concentricyst circulus* (Sample 34, 400x)
 Fig 18: *Bacculatisporites sp* (Sample 34, 400x)
 Fig 19: *Concentricyst circulus* (Sample 34, 400x)
 Fig 20: *Selaginella myosurus* (Sample 35, 400x)

PLATE 2

